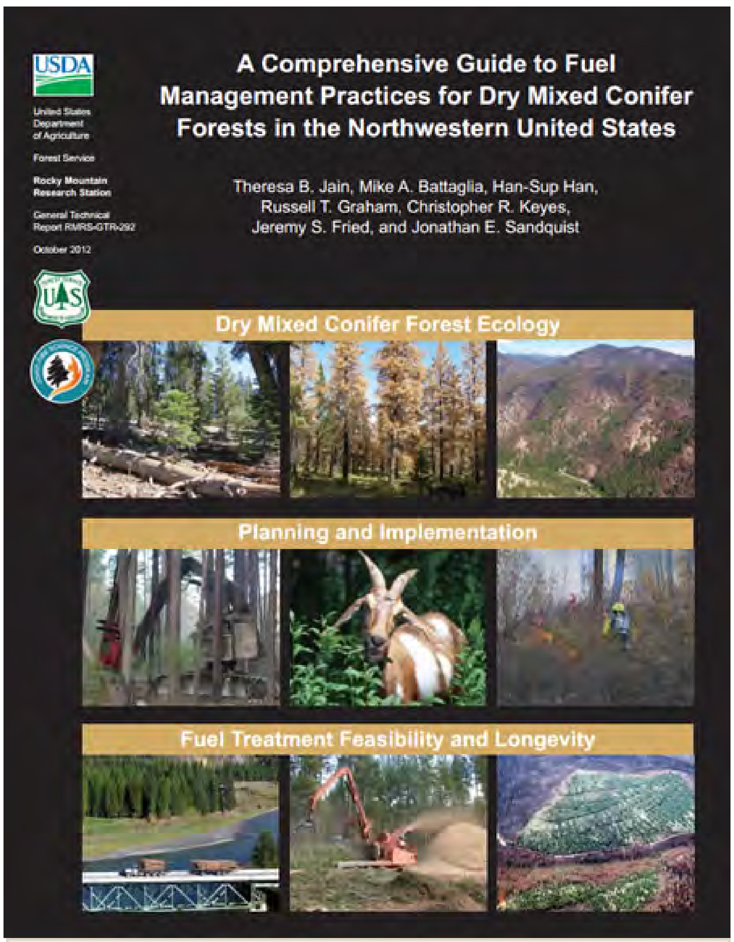
USDA
Science you can USE Bulletin
A Publication of the US Forest Service Rocky Mountain Research Station | January/February 2014 • ISSUE 9

Revisiting Disturbance: A New Guide for Keeping Dry Mixed Conifer Forests Healthy through Fuel Management

SUMMARY

Planning for hazardous fuels reduction can be challenging, given that land managers must balance multiple resource objectives. To help managers with planning and implementing fuel treatments, the Rocky Mountain Research Station, with support from the Joint Fire Science Program, has published A Comprehensive Guide to Fuel Management Practices for Dry Mixed Conifer Forests in the Northwestern United States (RMRS-GTR-292). Developed in close consultation with managers, the guide contains a synthesis of the best information on the management community's most frequently asked questions about how to: balance multiple resource objectives, understand and choose among the broad range of available treatment options (including considerations for prescribed burn plans and flow charts to guide the choice of equipment for mechanical treatment), develop an efficient and effective monitoring plan, and understand the trade-offs among longevity, effectiveness, and cost of various treatment options. The guide, though focused on fuel treatments, contains management options for addressing many issues across an important and diverse forest ecosystem.

From a wildfire's perspective, all live and dead vegetation is fuel and in dry mixed conifer forests of western North America, we have learned the hard way that trying to extinguish past fires has only served to create the accumulations of fuels that promote today's large and uncharacteristic wildfires. The 2002 Biscuit Fire (over 500,000 acres) in Oregon, the 2007 Cascade Complex (302,376 acres) in Idaho, and the 2006 Tripod Complex (113,011 acres) in Washington, provided compelling motivation to manage live and dead vegetation in order to alter how a fire burns through these forests.



The Joint Fire Science Program and the Rocky Mountain Research Station supported a state of knowledge synthesis concerning integrated fuels management in these widely-distributed, complex, and diverse, forest types resulting in the publication of ***A Comprehensive Guide to Fuels Management Practices for Dry Mixed Conifer Forests in the Northwestern United States*** *(RMRS-GTR-292).*

By strategically altering forest fuels, managers can often reduce wildfire damage to wildlife habitat, watersheds, and homes. However, fuel treatments can be difficult to plan and implement, given how many site-specific factors need to be considered, including economics, logistics, wildlife habitat, and safety. To assist managers with the choices and trade-offs involved in fuel management, the Joint Fire Science Program has supported the publication of several fuel management guides that cover selected U.S. regions.

Fuel management in the dry mixed conifer forests of the northwestern United States can be challenging. These forests cover a vast geographic area—over 37 million acres from the Black Hills in South Dakota to the Pacific Northwest—that includes portions of Northern California and the Klamath Mountains, the Pacific Northwest Interior, the northern and central Rocky Mountains, and Utah (see Figure 1). Also, a broad range of elevations, aspects, slopes, and species compositions are represented in these forests. The Joint Fire Science Program and the Rocky Mountain Research Station supported a synthesis of current knowledge concerning integrated fuels management in these widely-distributed, complex, and diverse forests, resulting in the publication A Comprehensive Guide to Fuels Management Practices for Dry Mixed Conifer Forests in the Northwestern United States (RMRS-GTR-292). This was produced by a team of research foresters from the USFS Rocky Mountain Research Station (Theresa Jain, Mike Battaglia, and Russ Graham) and their collaborators (Han-Sup Han, Humboldt State University; Christopher Keyes, University of Montana; and Jeremy Fried, USFS Pacific Northwest Research Station). Forestry technician Jonathan Sandquist with the Rocky Mountain Research Station also contributed to the guide. This guide incorporates extensive input from managers in the northwestern United States, including parts of the northern and central Rockies, and provides specific guidance on fuels treatment planning and implementation, and the feasibility and longevity of fuel treatments in the dry mixed conifer forest.

"We're putting young men and women out there to fight very large, dangerous, and sometimes unpredictable fires, made all the more so by excessive fuel, so firefighter safety is probably one of the biggest reasons we need fuel treatments," Graham noted.

DEFINING THE NEED FOR A GUIDE TO MANAGING FUELS IN DRY MIXED CONIFER FORESTS

Fuel treatments are not designed to stop wildfires, but to modify fire behavior to increase the likelihood of desirable post-fire outcomes (green trees and intact soils), provide more effective opportunities for fire suppression, and/or protect homes, drinking water and other values important to society. Another important reason to alter vegetation through fuels management is firefighter safety, according to Russ Graham, who has been working in this field for 38 years and has authored several reports investigating some of the West's most devastating wildfires. He suggests that social norms lead to firefighters attempting to save homes and other property, despite the often significant risks to their own safety. "We're putting young men and women out there to fight very large, dangerous, and sometimes unpredictable fires, made all the more so by excessive fuel, so firefighter safety is probably one of the biggest reasons we need fuel treatments," Graham noted. The continuing influx of new residents into the wildland-urban interface makes active fuel management a critically-important priority, if losses of life and property are to be reduced in these areas. Another important goal of fuel treatments is, according to Terrie Jain, "to protect our forests so that they still contain live trees, shrubs, grasses, forbs and productive soils that provide wildlife habitat and clean water."

One of the challenges of fuel management is that there is no "one-size-fits-all" approach that can be applied to these forests on a broad scale. The main goal of this guide is to synthesize the current science so it is accessible and useful to forest managers, and to provide information that stimulates critical thinking about options and informs decisions concerning fuels management strategies that integrate multiple objectives, including wildlife habitat, clean water, and recreational values. The researchers hope that every manager and those who make management decisions concerning dry mixed conifer forests will read, learn from, and consult this guide—and find it helpful. To ensure that the guide is relevant, the team interviewed over one hundred land and resource managers. Mike Battaglia pointed out, "Before we started writing, we went to the managers with a set of questions to figure out what was important to them, and which factors they consider when they treat fuels." Throughout the guide, manager experiences and anecdotes with fuels treatments appear as sidebars. "We wanted to have specific, relevant comments from the people implementing treatments," explained Jain, "and we chose to add these comments so readers can see that we provided information that

Figure 1. The geographic focus of this guide is the dry mixed conifer forests of Idaho, Montana, Wyoming, South Dakota, Utah, Oregon, Washington, and Northern California as highlighted in green above.

reflects the challenges and knowledge from the field."

The guide begins by describing the dry mixed conifer forests and the ecological characteristics that must be considered to develop effective management strategies. These forests occur over a very broad geographic range, with a great deal of variability in topography, climate, soils, and disturbance history. "This variation creates a forest mosaic that looks different from the expansive pure stands of ponderosa pine found elsewhere in the western United States," according to Jonathan Sandquist. For example, in the Northern California and Klamath Mountains region, dominant tree species include Douglas-fir, incense cedar, sugar pine, and western white pine, whereas in Utah, you are more likely to find Douglas-fir growing with aspen, lodgepole pine, ponderosa pine, white fir, and subalpine fir. The first section of the guide characterizes these ecological settings by describing the 20 different vegetation types that comprise dry mixed conifer forests by region, and discusses the role of disturbance (e.g., disease, insects, and human activity), climate, and the impacts of past management,

Battaglia pointed out, "Before we started writing, we went to the managers with a set of questions to figure out what was important to them, and which factors they consider when they treat fuels."

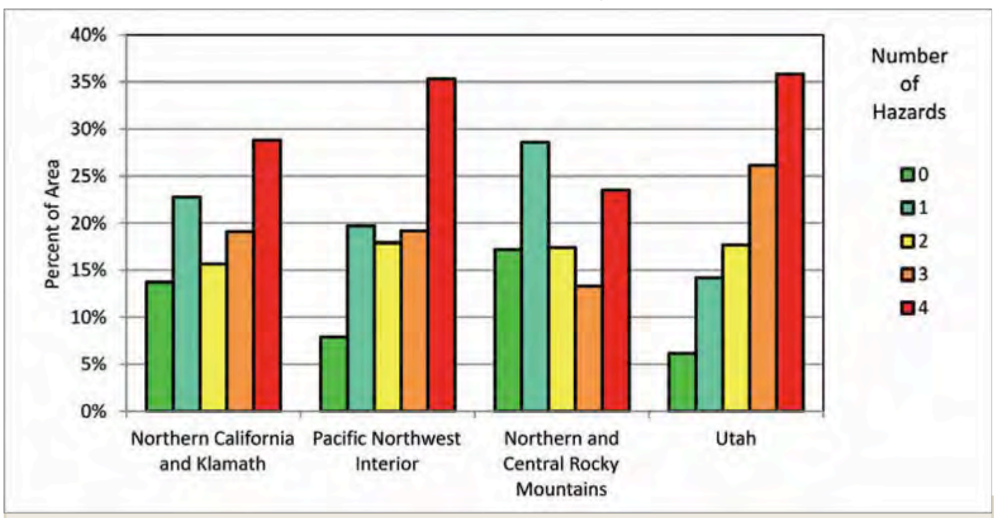
Fire suppression promotes the regeneration of shade-tolerant species and creates the need for fuels treatments as shown here in the Boise Basin Experimental Forest (left, photo credit: Jonathan Sandquist) and the Crane Mountain Roadless area, Oregon (right, photo credit: Andris Eglitis)

all of which have played a major role in creating the forests we see today.

Historically, dry mixed conifer forests were characterized by low- and mixed-severity wildfire regimes, but fire suppression has created accumulations of fuels in some areas. To understand the scope of the current fuels treatment challenge in these forests, FIA (Forest Inventory and Analysis) scientist Jeremy Fried provided a characterization of the current fire hazard using data collected by the FIA Program. According to Fried, understanding the current fire hazard conditions in these forests is a critical first step that should precede assessing treatment options, evaluating the cost of these treatments, and quantifying any potential offsetting revenues—topics that are covered in later portions of the guide. Looking at FIA's statistically-representative sample of the forested landscape, he found that most of the area would benefit from some level of treatment to reduce the fire hazard. Up to 80 percent of the dry mixed conifer forests contained at least one of the defined hazard elements and up to 20 to 30 percent contained all four (see graph for an explanation of the hazard elements). This analysis is supplemented with an appendix of information-rich histogram graphics, which are organized by subregion and forest-type group. Managers can rely on this information as a useful baseline against which any individual stand can be compared. One can ask, for example, 'is this stand at the high end of the hazard spectrum or somewhere in the middle relative to the rest of the forests of similar type in the area?'

PLANNING AND IMPLEMENTING FUELS TREATMENTS IN THESE FORESTS

One key challenge for many managers planning fuel treatments is that



The guide contains an analysis of the current fire hazard conditions in the dry mixed conifer forest, by region, as a tool for assessing the need for fuels treatment in this area. Four hazard aspects were considered: 1) probability of torching in severe conditions, 2) torching index (the wind speed at which crown fire initiation would be expected), 3) surface flame length (as a proxy for fire intensity and fire suppression effectiveness), and 4) mortality volume (as an indicator of economic and resource loss). The hazard score is based on number of hazards that exist in a given location; a hazard score of 4 indicates that an acre is subject to all four hazards.

"The managers agreed that actually implementing fuels treatments was not nearly as difficult as the detailed, and sometimes complex, planning process that leads up to implementation, given the broad range of resource objectives that must be considered," Jain noted.

Mechanical treatments reduce understory fuels. These photos show the Warm Lake Highway Project in Idaho before treatment (top), during mulching of surface and ladder fuels (middle), and after treatment (bottom) (photo credit: Graham et al, 2009).

wildlife and other resources must be considered directly alongside hazard and fuel reduction goals. For example, the "multiple use" mandate (from the Multiple Use Sustained Yield Act of 1960), which helps to define the mission of the Forest Service, also influences decisions associated with fuels management. "During the interview process, the subject of planning kept coming up," recalled Jain. "The managers agreed that actually implementing fuels treatments was not nearly as difficult as the detailed, and sometimes complex, planning process that leads up to implementation, given the broad range of resource objectives that must be considered." To address this, the guide includes a planning section which details how vegetation managers can help provide for wildlife needs when planning fuels treatments, and how fuel treatments may be integrated with other objectives through a series of steps including: clearly defining management objectives, translating these objectives into various alternatives, assessing the benefits and trade-offs, and then finally, designing the fuel treatments to meet these objectives. Graham suggested that this is not as complicated as it might seem. From his perspective, managing fuels, managing timber, and managing wildlife on a site will all involve a planned series of treatments through the life of the forest; each treatment may have a different objective, but over the long term those objectives may not be incompatible. He explained, "You have to have all of the people who are working on these things in the same room talking to each other to plan for the desired condition. It might seem difficult, but I suggest it's not if you really want to do it."

A key decision point in fuels treatment planning is selecting the best approach for altering and removing live and dead vegetation. The two most common choices are prescribed fire (excess fuel is removed by combustion) and mechanical fuel treatment (excess fuel is mechanically removed or modified). Prescribed fire can be cost-effective and, since fire has always played a role in this landscape, it can be seen as closely mimicking a natural process in many cases. The guide provides information on prescribed-fire use in this region, including discussion of developing a burn plan, implementing fire, and unique forest attributes that favor specific post-fire outcomes. Comments from managers are featured prominently in this chapter (Chapter 9), and the importance of expert knowledge is stressed throughout in determining when to ignite a prescribed fire. One manager quoted in this section advised: "When developing a burn plan, it needs to be specific enough to successfully implement the burn, but allow enough flexibility that the project is not pushed into a corner, losing sight of the scope and purpose of the burn. It's a matter of finding the right balance."

Prescribed fire can be a hard sell in many communities—one mistake can set back acceptance of the approach for a long time to come—and the timing must be such that the winds speeds are low and the fuels are neither too wet nor too dry. Partly because of these realities, mechanical methods are more frequently chosen in most areas. Through interviews, the researchers learned that managers need guidance on how best to implement mechanical treatments in dry mixed conifer forests. This treatment usually involves the deployment of large, mechanized equipment and can be expensive. In some cases, the volume of the timber harvested as part of the treatment may be sufficient to cover treatment costs, and even produce revenue in excess of costs, but some mechanical treatments do not produce much, if any, commercially-valuable timber. Professor Han-Sup Han estimated that the cost of mechanical treatment ranges from $150 to over $2000 per acre, and that costs are greatest when access is difficult, the ground is steep, and there is a lot of material to be removed or modified. "You can't just cut trees down and leave them, you may have to haul them out, grind and spread them," he says, which adds to the cost. In his conversations with managers, Han found that many sought information about which types of equipment to use. "My answer was, usually, it depends

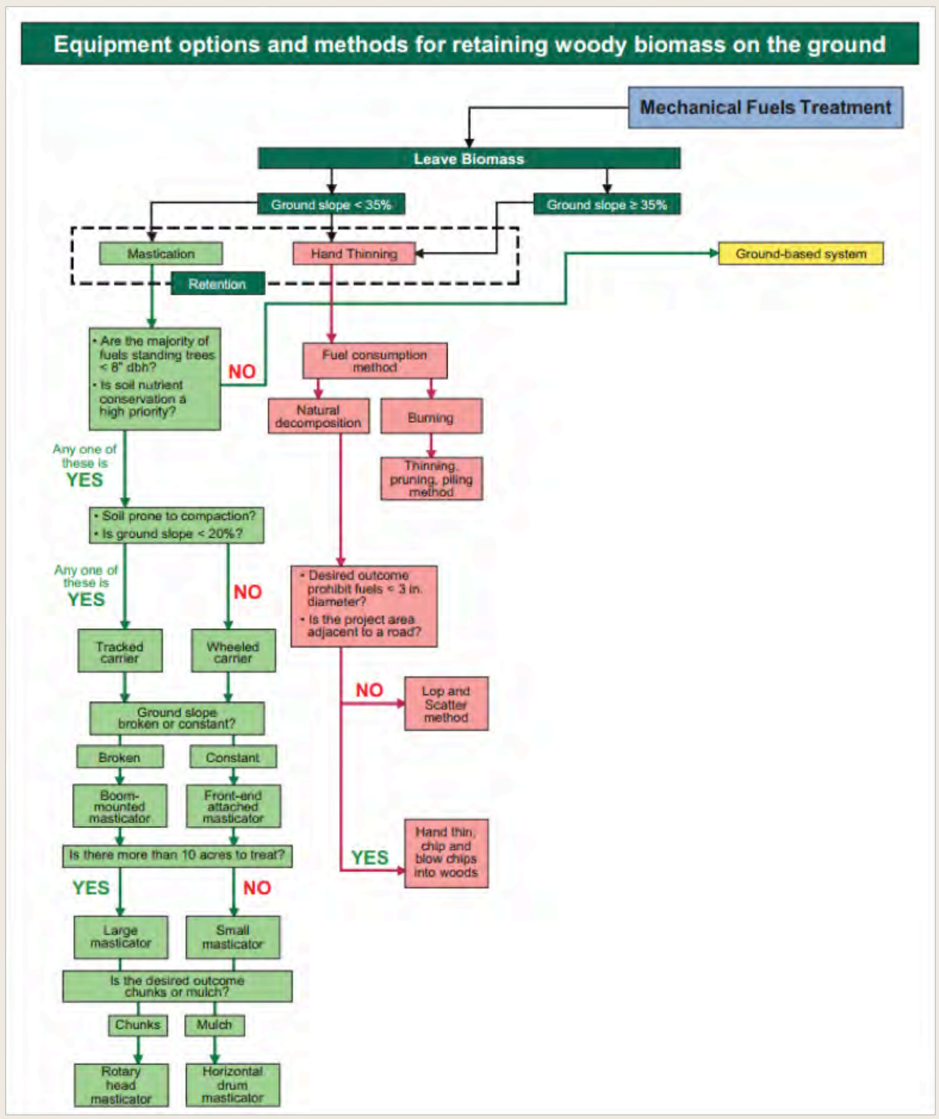


Figure 2. This flow chart, as found in p. 143 of the guide, illustrates the process of selecting a mechanical fuels treatment when leaving biomass on the site. The other side of this chart (not shown here but found on p. 144 in the guide) shows the sequence of decisions to be made when selecting a mechanical fuels treatment and removing biomass. Combined with the information in the guide itself, this flowchart can serve as a resource that may help managers make decisions regarding treatments designed to alter fire severity and behavior.

what you want to do and how, and the current situation you have on site. But they wanted more specific answers and a strategy for selecting the best equipment for specific jobs." To meet this need, Han created a systematic approach for selecting equipment for different situations and purposes in the form of a series of flow charts that guide situation specific equipment choices. The charts are included as part of this fuels treatment guide (see Figure 2) in the hope that they will serve as a useful planning tool.

Prescribed fire or mechanical treatments are not the only options for altering fuels; the use of biological and chemical alternatives is also addressed in this guide. For example, goats (and other ungulates) or herbicides can alter surface fuels where other mechanical techniques may not appropriate, effective or feasible. Space precluded a lengthy discussion of each of these techniques, but Jain noted that a goal of the guide was to be a portal for managers and landowners to other relevant information, which is compiled at the end of each chapter.

Monitoring the effectiveness of fuel treatments is important because, as Fried states, "We spend a lot of taxpayer money making fuels treatments happen on public land, and it behooves us to seek evidence that indicates whether what we're doing is making a difference." Monitoring plays an important role at two levels. On the surface, we can ask, did the treatment accomplish the intended objectives in terms of changing the structure of canopy and surface fuels so that, say, the probability of a severe, crown fire is reduced? "At this level, once we conceptualize what the fuel treatment should look like, come up with a prescription, and execute a contract to implement the treatment, we can go back afterwards and take a look at it to ensure it accomplished what we intended and expected," Fried explained. At a deeper level, we can monitor what occurs after an area burns, and compare pre- and post-fire conditions in places that were treated and not treated to get a sense of the extent to which fuel reduction reduced unwanted fire behavior. The guide acknowledges that time and funding to conduct monitoring are too often limited, but suggests that a well-designed monitoring protocol can help to maximize return on investment. To this end, the guide covers the most important aspects of developing a monitoring plan, including the most important questions to consider, the elements of a monitoring design, and the payoff of investing in a statistically-representative sampling effort. The information that can be gained from monitoring fuels treatments is integral to achieving an effective and efficient fuels management program over the long haul.

Fried states, "We spend a lot of taxpayer money making fuels treatments happen on public land, and it behooves us to seek evidence that indicates whether what we're doing is making a difference."

THE REALITY CHECK ON FUEL MANAGEMENT OPTIONS: ECONOMICS AND LONGEVITY OF TREATMENTS

In the past several decades, the cost of fighting wildfires has increased dramatically, due to a variety of factors. In recent years, almost half of the U.S. Forest Service budget has been spent on wildfire suppression. Although systematic implementation of fuel treatments has potential to reduce firefighting costs, today's reality is that the extensive area in need of costly fuel treatments exceeds the budget available for these treatments on most National Forests. In the final section of the guide, the scientists sought to estimate how much of the dry mixed conifer forest in the Northwest U.S. can feasibly receive effective treatment and the extent to which such treatments can cover costs via sales of merchantable wood and bioenergy. Fried used a modeling approach based on FIA data to compute hazard ratings, treatment cost models, fuel treatment effectiveness criteria, and a raw-material hauling cost model to explore various treatment scenarios for this guide. He found that effective, hazard-reducing treatment was technically possible in some of these forests (roughly 35 to 60 percent, depending on the subregion), with the remainder resistant to hazard reduction due to initial stand structure or accessibility issues. Of this treatable area, only a third to half could be treated with costs fully covered by sales of products. He sums it up thusly: "The number of places where you can go out and achieve effective treatment at reasonable cost is lower than you might like or expect." One important conclusion from this analysis is that it is important to consider the economics of fuel treatment options and pursue all options that promote self-funding treatments (e.g., with revenues coming from using removed material for wood products or biofuel) given the current and probable future budgets for this type of work.

Another aspect of the economics and feasibility of fuels treatments is how long the treatments will last, without renewal, before their effectiveness dissipates. According to Chris Keyes, we haven't been doing fuel treatments for all

"You don't have to, say, read chapter three to understand chapter four. If you have a question about planning, or integrated fuel treatments, you can just pick it up and read that portion," notes Battaglia.

that long, so in the past managers may have been satisfied with projects that showed a positive effect in the short- to medium-term. But now that we have fuel treatments that are 10-15 years old, managers increasingly understand the need to assess and predict fuel treatment longevity, and to incorporate this information in communications with interested stakeholders during the decision process. He explained, "What's left behind after a treatment is a dynamic complex of live and dead plants that continue to change. So as soon as we walk away, we have elements that are expanding or increasing, some that are degrading or deteriorating, and some that are shifting from one fuel type to another—for example, live trees die, transition into snags, and eventually fall and convert into down wood and surface fuel. Such changes have direct, and sometimes profound, impacts on fire behavior that determine the effectiveness of the treatment." He further explained there is a trade-off between a fuel treatment's short-term effects and its longevity. For example, when implementing a treatment that produces a great initial impact (i.e., many trees are removed), ladder fuel amounts can recover quickly because removal of trees produces more sunlight where the seedlings and saplings grow. The final chapter of the guide discusses these trade-offs, and how managers might go about balancing these competing objectives by planning fuel treatment regimes over the longer term.

The diverse manifestations of dry mixed conifer forests (e.g., with respect to age, structure, understory and species composition) preclude a single prescriptive fuel treatment recipe that can be widely and consistently applied. With this in mind, the guide is intended to provide information and tools to managers so they can develop the fuel treatments that best match the dry mixed conifer forests that they manage, and the local resource objectives, social values and economic realities. Specifically, the researchers suggest that the guide would be of particular use to fuel specialists, but that most resource specialists—from silviculturists to wildlife biologists—would find it helpful. No one should be intimidated by the guide's heft, said Mike Battaglia. "You don't have to, say, read chapter three to understand chapter four. If you have a question about planning, or integrated fuel treatments, you can just pick it up and read that portion." An important additional component of the fuels management guide is a web-based interactive literature list that provides links (where available) to the background literature used and allows users interested in digging deeper in any topic area to quickly access the original source. Since all live and dead vegetation is fuel, the scientists who produced this guide will consider it a success if managers, decision makers, policy makers and the public can rely on it for the latest and most relevant information they need for managing these forests.

KEY SECTIONS OF THE GUIDE

Section I. Ecology of Dry Mixed Conifer Forests

- Potential Vegetation and Biophysical Setting
- The Role of Disturbance and Climate
- Actions and Impacts of Past Management
- Inventory Modeling of Current Fire Hazard Conditions

Section II. Fuel Treatment Planning and Implementation in Dry Mixed-Conifer Forests of the Northwestern US

- Integrating Wildlife Habitat into Fuels Planning and Implementation
- Planning and Conducting Integrated Fuel Treatments
- Mechanical, Chemical, and Biological Fuel Treatment Methods
- Prescribed Fire
- Monitoring

Section III. Reality Check: The Economics, Feasibility, Longevity, and Effectiveness of Fuel Treatments

- Inventory and Model-Based Economic Analysis of Mechanical Fuel Treatments

SELECTED MANAGER COMMENTS FROM THE GUIDE

The researchers who wrote this guide intend for it to be a useful and practical reference for managers who are attempting to integrate multiple resource objectives. As such, they developed the content in close consultation with a variety of resource managers—from vegetation managers and fire management officers to wildlife biologists, hydrologists, and forest staff officers, to name a few. This list represents a selection of manager comments that the researchers found helpful in framing the guide's content and maximizing its utility to the management community.

- "There are many decision support tools and all must have a use, otherwise they would not have been developed. However, some are too complicated or cumbersome and there is insufficient time to learn them or use them effectively. The tools that are commonly used tend to have regional or national support."
- "The job of the fuels specialist is to work with a wildlife biologist and silviculturist to quantify the risk of habitat loss from severe wildfire with and without treatment and weigh those risks against the impacts from a fuel treatment. In this way, the decision maker can make informed decisions and communicate about relative risk to the habitat."
- "Spatial context is crucial when designing fuel treatments to reduce the likelihood of crown fire. Nature is messy and not all treatments need spacing between all trees on a given site. Spacing between clumps of trees will effectively minimize sustained crown fires and sometimes the clumpy nature of these stands provides habitat elements as well."
- "Most deliberate human-caused ignitions prior to 1850 were in late-winter/early spring and in fall, before and after the primary growing season. Accidental human-caused fires could occur at any time of the year (escaped campfires). Deliberate human ignitions during the growing season were most often acts of war, intended to drive enemies or deprive them of cover or food. We need to stop pretending that human-caused fires did not occur over the last 15,000+ years."

FURTHER READING

Jain, Theresa B.; Battaglia, Mike A.; Han, Han-Sup; Graham, Russell T.; Keyes, Christopher R.; Fried, Jeremy S.; Sandquist, Jonathan E. 2012. A comprehensive guide to fuel management practices for dry mixed conifer forests in the northwestern United States. Gen. Tech. Rep. RMRS-GTR-292. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 331 p.

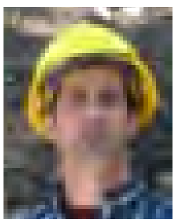
A comprehensive guide to fuel management practices for dry mixed conifer forests in the northwestern United States. Interactive Literature List for RMRS-GTR-292, http://www.fs.fed.us/rm/pubs/rmrs_gtr292/rmrs_gtr292_references.html

WRITER'S PROFILE

Sue Miller *is a science writer living in Fort Collins, Colorado. She received her Ph.D. in ecology from the University of Georgia. Sue can be reached at millroad@comcast.net.*

SCIENTIST PROFILES

THERESA JAIN is a Research Forester in the Forest and Woodland Ecosystems Science Program at the Rocky Mountain Research Station, U.S. Forest Service, Moscow, Idaho. She received her Ph.D. in Silviculture with an emphasis on landscape ecology and applied statistics, Master of Science degree in Silviculture with emphasis on soil processes, and a Bachelor of Science degree in Forest Management, all from the University of Idaho. Currently her research focuses on developing, implementing, and evaluating alternative silvicultural management strategies for addressing integrated fuel treatment and restoration objectives in moist and dry mixed conifer forest.



MIKE A. BATTAGLIA is a Research Forester in the Forest and Woodland Ecosystems Science Program at the Rocky Mountain Research Station, U.S. Forest Service, Fort Collins, Colorado. He has a Ph.D. in Silviculture and Fire Science from Colorado State University, Master of Science in Forestry from Virginia Tech, and a Bachelor of Science degree in Biology from the University of South Carolina. Mike's research focuses on developing and implementing innovative management strategies that address the challenges and issues faced by forest managers.

HAN-SUP HAN is currently a Professor in the Department of Forestry and Wildland Resources, Humboldt State University (HSU), Arcata, California. He received his Ph.D. in Forest Engineering from Oregon State University, Corvallis. He received two Master of Science degrees: Forest Ecology from Kangwon National University, South Korea; and Forest Operations from the University of Maine. He received a Bachelor of Science degree in Forestry from Kangwon National University, South Korea. His primary area of research interest relates to economic analysis and environmental impact assessments of forest harvesting operations.

RUSSELL T. GRAHAM has over 35 years of experience as a Research Forester with the Rocky Mountain Research Station. Russ is with the Forest and Woodland Ecosystems Science Program in Moscow, Idaho. He received his Ph.D. in Silviculture in 1981 and a Master of Science degree in Silviculture in 1976, both from the University of Idaho. Dr. Graham has published over 200 scholarly articles with his principle research focusing on long-term forest productivity, landscape processes, and wildlife habitat.

Mike can be reached at:

USDA Forest Service
Rocky Mountain Research Station
240 W Prospect Rd
Fort Collins, CO 80526
(970) 498-1100

Teresa (Terrie) and Russell can be reached at:

USDA Forest Service
Rocky Mountain Research Station
1221 S. Main St.
Moscow, ID 83843

SCIENTIST PROFILES *cont.*

CHRISTOPHER R. KEYES is a Research Associate Professor of Silviculture at the University of Montana, in Missoula, Montana. He received a Ph.D. in Silviculture from Oregon State University and a Master of Science degree in Silviculture from the University of Montana. As director of the Montana Forest and Conservation Experiment Station's Applied Forest Management Program, he develops and promotes silvicultural tools and techniques for the stewardship, restoration, and renewal of western forests.

JEREMY S. FRIED is a Research Forester in the Resource Monitoring and Assessment Program at the Pacific Northwest Research Station, U.S. Forest Service, Portland, Oregon. He has a Ph.D. in Forest Management and Economics and a Bachelor of Science degree in Forestry from the University of California–Berkeley and Master of Science degree in Forest Ecology and Soils from Oregon State University. He applies systems analysis, geographic information science and economics to forest inventory data to address contemporary natural resource management issues involving fire and fuels, climate change mitigation, and woody biomass supply.

JONATHAN E. SANDQUIST is a Forestry Technician in the Forest and Woodland Ecosystem Program at the Rocky Mountain Research Station. Jonathan has a Bachelor of Arts degree from Evergreen State College, Master of Science degree in Environmental Science from Washington State University, and GIS Certificate from the University of Idaho. He has worked the past 10 years supporting silviculture research. His skills are in data management, preparing manuscripts, and GIS and FFE-FVS analysis.

PURPOSE OF THE SCIENCE YOU CAN USE BULLETIN

To provide scientific information to people who make and influence decisions about managing land. The US Forest Service RMRS Science You Can Use Bulletin is published regularly by:

Rocky Mountain Research Station (RMRS)
US Forest Service
240 W Prospect Rd
Fort Collins, CO 80526

Forest Service researchers work at the forefront of science to improve the health and use of our Nation's forests and grasslands. RMRS is one of seven Forest Service R&D Stations located throughout the US. For more information about a particular research station, please visit their website:

Northern Research Station (NRS)
Southern Research Station (SRS)
Rocky Mountain Research Station (RMRS)
Pacific Northwest Research Station (PNW)
Pacific Southwest Research Station (PSW)
International Institute of Tropical Forestry (IITF)
Forest Products Lab (FPL)

PNW and SRS produce regular science delivery bulletins similar to the Science You Can Use Bulletin:

PNW Science Findings
SRS Compass Live

To receive this bulletin via email, scan the QR code below or use this link:
http://tinyurl.com/RMRSsciencebulletin

Sarah Hines, Bulletin editor; shines@fs.fed.us

Jan Engert, Assistant Station Director,
Science Application & Integration;
jengert@fs.fed.us